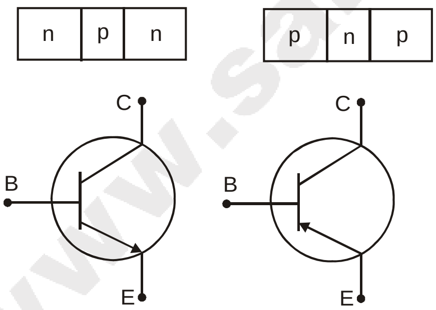
2.TRANSISTORS:

1. **Transistors:** A transistor is formed by sandwiching a thin layer of a p-type semiconductor between two layers of n-type semiconductors or by sandwiching a thin layer of an n-type semiconductor between two layers of p-type semiconductors.
2. Transistor means "Transfer of resistance" and is invented by John Bardeen, W.H. Brattain and William Shockley in 1948.



3. Transistors are of two types i) n-p-n, ii) p-n-p
4. Transistor will mainly consists of three sections i) emitter, ii) base, iii) collector.
5. **Emitter :**
   a) It is heavily doped to get more number of majority charge carriers.
   b) Width of this region is slightly less than that of collector region.
   c) Its function is to supply majority carriers to the base.
6. **Base :**
   a) It is the middle section of the transistor.

b) It is slightly doped.

c) Width of this region is very thin (of the order of 10^{-6} m)

d) Its function is to inject majority carriers to the collector.

7. **Collector :**

a) It is moderately doped.

b) Width of this region is moderate of all regions to get large number of charge carriers.

c) Its function is to collect majority carriers from the base.

d) In a transistor emitter region and collector region cannot be interchanged.

In a circuit p-n-p, n-p-n transistors are represented as follows:

e) In a transistor, the arrowhead should always be at the emitter base junction, which represents the direction of flow of conventional current.

f) In a transistor, emitter-base junction should be forward biased and collector-base junction should be reverse biased.

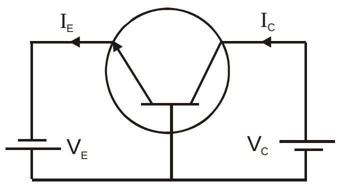
g) In an n-p-n transistor, the direction of current is from base to emitter.

h) In a p-n-p transistor, the direction of current is from emitter to base.

i) **Emitter current & Collector current:** The electrons going from the battery V_E to the emitter constitute the electric current I_E in the opposite direction. This is known as emitter current. Similarly, the electrons going from the collector to the battery V_C constitute the collector current I_C. Similarly for the holes which move in the opposite direction but result in the current in the same direction in p-n-p transistor.

Working of a transistor :

8. Consider a n-p-n transistor connected to the proper biasing. The emitter base junction is forward biased, so electrons are injected by the emitter into the base. The thickness of the base region is so small that most of the electrons diffusing into the base region cross over into the collector region. The reverse bias at the base collector junction helps this process, because as the electrons appear near this junction they are attracted by the collector. These electrons go through the batteries V_C and V_E and are then back to the emitter.



9. Cross sectional area of base is very large as compared to emitter. Cross sectional area of collector is less than base but greater than emitter.

10. Transistor can be connected in three different configurations.

i) Common base configuration

ii) Common emitter configuration

iii) Common collector configuration

a) In any transistor circuit $I_E=I_B+I_C$.

b) In common base configuration transistor, the current gain is $\alpha_{a.c} = \frac{\Delta I_C}{\Delta I_E}$.

c) In common base configuration transistor α value is less than 1 (α<a).

d) The practical value of α lies between 0.95 to 0.995.

e) In common-emitter configuration transistor, the current gain is $\beta_{a.c} = \frac{\Delta I_C}{\Delta I_B}$.

f) The value of β is greater than one (β>a).

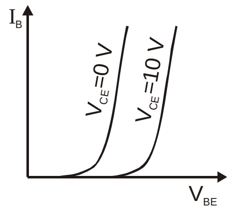
g) The practical value of β lies in between 20 to 500.

h) Relation between α, β : $\beta = \frac{\alpha}{1-\alpha}$; $\alpha = \frac{\beta}{1+\beta}$.

11. **Characteristic Curves :**

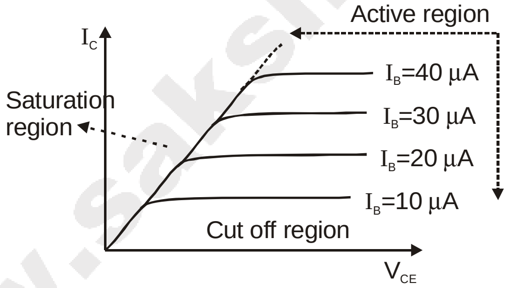
a) For a common emitter configuration transistor, the curves showing the variation of base current $(I_{2)}$ with base-emitter voltage (V_{BE}) at constant collector voltage (V_{CE}) are called as input characteristic curves.

b) Input characteristic curve :



c) Input resistance in CE configuration transistor is $R_i = \left(\frac{\Delta V_{BE}}{\Delta I_B}\right)_{V_{CE}}$

d) For a common-emitter configuration transistor, the curves showing the variation of collector current $(I_{3)}$ with collector-emitter voltage (V_{CE}) keeping base current $(I_{2)}$ constant are called output characteristics curves.



e) Output characteristic curve :

f) The output resistance in C-E configuration transistor is $R_o = \left(\frac{\Delta V_{CE}}{\Delta I_C}\right)_{I_B}$

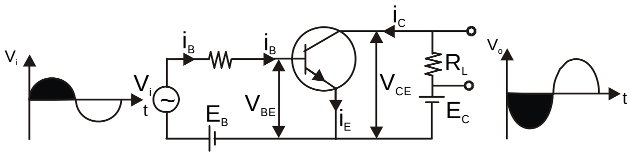
12. The collector set of characteristics has three regions of interest.

a) **Saturation region :** In this region the collector current becomes almost independent of base current. This happens when both junctions are forward biased.

b) **Cut off region :** In this region the collector current is almost zero. This happens when both junctions are reverse biased.

c) **Active region :** In this region collector current I_c is may times greater than base current $(I_{2)}$. A small change in input current (ΔI_b) produces a large change in the output current (ΔI_c). This happens when emitter junction is forward biased and collector junction is reverse biased. The transistor works an amplifier when operated in the active region.

13. C-E configuration transistors are widely used as amplifiers because of its higher efficiency over the other configurations.



14. The process of raising the strength of weak signal is known as amplification and the device which accomplishes this job is called amplifier. The phenomenon of amplification is necessary in radio communication systems.
15. Figure shows an amplifier circuit using n-p-n transistor in common emitter mode. The battery E_B provides the biasing voltage (forwar4) V_{BE} for the base-emitter junction. The potential difference V_{CE} (reverse bias) is maintained between collector and the emitter by the battery E_C. The base - emitter junction is forward biased and so the electrons of the emitter flow towards the base. As the base region is very thin (of the order of micrometre) and the collector is also maintained at a positive potential, most of the electrons cross the base region and move into the collector. The current i_C is about $0.95i_E$ to $0.99i_E$. A small change in the current i_B in the base circuit controls the larger current i_C in the collector circuit. This is the basis of amplification with the help of a transistor.
16. The input signal, to be amplified, is connected in series with the biasing battery E_B in the base circuit and output is taken across load resistor (R_L).
17. **Current gain β :**

Current gain $\beta = \frac{\Delta i_C}{\Delta i_B}$

β lies between 20 to 500.

18. **Voltage gain A_V** : The voltage gain is the ratio of change in output voltage (ΔV_{CE}) to the change in input voltage (ΔV_{BE}).

Voltage gain $A_V = \frac{\Delta V_{CE}}{\Delta V_{BE}}$

19. **Power gain A_P** : Power gain is the ratio of output signal power to the input signal power.

A_P = current gain x voltage gain.

20. **Amplification factor A** $= \frac{e_o}{e_i}$ where e_i = input voltage, e_o = output voltage
21. The performance of a transistor amplifier depends upon input resistance, output resistance, collector load, current gain, voltage gain and power gain.